quantity of dopant in each vertical section **30,32** is less than that needed to produce the breakdown field. After the region is fully depleted horizontally, the field continues to build vertically until it reaches the avalanche field of approximately 20 to 30 volts per micron.

The horizontal thickness B of the vertical sections **30,32** should be as small as possible consistent with the method used to form them and must be smaller than the vertical thickness A of the blocking layer **16**. The distance between vertical sections of the same conductivity is the pitch of the device and is equal to the horizontal thickness B of the vertical sections of the other conductivity. As shown in the embodiment of FIG. **5**, the sections **30,32** have the same horizontal thickness, but different thicknesses may also be used. If one section is thicker than the other, it is preferred to have the current-carrying section be the thicker section. For example, in an N channel device, it is preferred to have thicker N sections, and similarly, in a P channel device, it is preferred to have thicker P sections.

The dopant concentration of the vertical sections **30,32** should be as high as possible (to make the vertical resistance as low as possible) but must be low enough so that breakdown voltage is not reduced. The primary limitation on the maximum dopant concentration is that the concentration in each vertical section must be low enough so that the depletion region can spread horizontally across the entire horizontal thickness B of the vertical sections **30,32** before the horizontal electric field reaches the critical field. The horizontally integrated dopant concentration of each vertical section must be kept below a value of about 2 to 4E12/cm2. The critical field is around 20 to 30 volts per micron which corresponds to an integrated charge of 1.2 to 1.8 electronic charges per square centimeter. Because each vertical section is depleted from both sides, the sections can contain twice that number of dopant atoms.

The exact value of the critical field depends on several factors, including dopant concentration, carrier mobility, section thickness, and ionization integral. As a result of different ionization integrals, the critical field in the vertical direction may be significantly different than the critical field in the horizontal direction. Because the vertical field extends over a long distance, the ionization integral is large, i.e., each free carrier can travel a long distance and can generate a large number of additional free carriers. As a result, the critical field in the vertical direction is about 20 volts per micron. In the horizontal direction, the critical field is closer to 30 volts per micron because the ionization integral is low (short distance for free carrier travel) and the field can be somewhat higher before avalanche breakdown occurs. Thus maximum allowable dopant concentration is higher as the vertical sections are made thinner.

During depletion, the field reaches the critical field of 20 to 30 volts per micron over the entire vertical extent of the blocking layer. In the prior art, the field reaches the critical field only at the P-N junction and then tapers for an average field of 10 to 15 volts per micron across the total thickness of the blocking layer. Thus the vertical thickness of the blocking layer of the VDMOS MOSFET in accordance with the present invention may be less than the vertical thickness of the prior art device.

In addition to being thinner, the blocking layer of the present invention has a lower resistance than the blocking layer of the prior art device because current flows vertically through the N sections **32**. When breakdown voltage is increased in the present invention, the on-resistance of the device increases only linearly with breakdown voltage as compared to the prior art device where on-resistance increases by a factor equal to the increase in breakdown voltage raised to the power of approximately 2.3. FIG. **6** is a graphical comparison of specific resistance (on-resistance multiplied by area) for a given breakdown voltage of the prior art device and several embodiments of the present invention.

FIG. **7** illustrates another embodiment of the blocking layer **16** in accordance with the present invention. In this embodiment, the blocking layer **16** comprises a horizontal layer **34** of one conductivity type material (N type as illustrated) with vertical sections **36** of a second conductivity material (P type as illustrated). In this embodiment, the vertical sections **36** are cylinders and are uniformly positioned throughout the layer **34**. The vertical sections **36** may have horizontal cross-sections other than the circles illustrated. The horizontal distance C between the vertical sections **36** must be smaller than the vertical thickness A of the blocking layer **16**.

With the exception of the blocking layer **16**, conventional VDMOS processing technology may be used to fabricate the MOSFET **10**.

The blocking layer **16** may be fabricated by beginning with an epitaxial layer of one conductivity type (N type for example) and implanting dopant of a second conductivity type (P type for example) to form the vertical sections **32** or **36**. The second conductivity type dopant may be implanted using a thick implant mask or a focused ion beam.

In one embodiment, for a 1000 volt device with a 10 micron pitch, the epitaxial layer could have a thickness of 55 microns and a dopant concentration of 4E15/cm3 (1.2 ohm cm) on an N+ substrate. Boron is then implanted with the implant energy varied from several Kev to about 70 Mev to distribute the boron vertically in sections **32** or **36**. The total dose required is about 2E13/cm2 for a masked implant, and about half this value for a focused ion beam implant.

While preferred embodiments of the present invention have been described, it is to be understood that the embodiments described are illustrative only and the scope of the invention is to be defined solely by the appended claims when accorded a full range of equivalence, many variations and modifications naturally occurring to those of skill in the art from a perusal hereof.

What is claimed is:

1. A vertically conducting high voltage MOSFET having a voltage supporting region comprising a horizontal layer having an avalanche breakdown voltage, wherein if the electric field in said layer reaches said avalanche breakdown voltage, the electric field over substantially the entire vertical thickness of said layer reaches said avalanche breakdown voltage.

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